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DESIGN OF 12-INCH EXTRUSION PRESS

U. S. NAVAL PROPELLANT PLANT INDIAN HEAD, MARYLAND

POLARIS PROJECT MANAGEMENT OFFICE

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DESIGN OF 12-INCH EXTRUSION PRESS

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FOREWORD

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ABSTRACT

Based on design studies for a high-energy propellant extrusion press completed during fiscal year 1962 by the Farrel-Birmingham Company, Inc. and the Ferracute Machine Company, engineering drawings and specifications are presented which represent a composite of the best features submitted by the two press manufacturers. This design incorporates positive ram head-to-basket alignment and safety features which will minimize, if not eliminate, the possibility of an explosion and subsequent major damage.

DESIGN OF 12-INCH EXTRUSION PRESS

The objective of this task was to develop a design for a vertical extrusion press capable of processing high-energy casting powder safely and efficiently.

The loss of four 12-inch extrusion presses and consequent facilities damage in the period 21 September 1960 to 11 May 1962 resulted in facilities and equipment monetary losses of approximately \$400,000, exclusive of loss of production capability and the deleterious effect on personnel morale.

The heavy incidence of fires experienced with the presently used extrusion presses, in spite of considerable improvement in some features of their design, made it imperative to investigate basic press designs to provide a replacement for presses designed in 1938 for use in the extrusion of single-base propellants. A conference on the state-of-the-art of propellant extrusion was held at the Naval Propellant Plant (NPP) on 28 February 1962 and was attended by leaders in the propellant extrusion field, both propellant processors and press manufacturers. With funding provided by the Special Projects Office, contracts were let with two press manufacturers, Watson-Stillman Press Division of Farrel-Birmingham Company, Inc. and Ferracute Machine Company, to provide design studies and preliminary drawings of an extrusion press based on design criteria established by NPP personnel. Both of these manufacturers submitted proposals at the end of fiscal year 1962.

DISCUSSION

The Watson-Stillman and Ferracute press design proposals were analyzed by personnel from all divisions at NPP which are concerned with actual production or safety of operations in high-energy casting powder manufacture. Both press manufacturers agreed that an equally-loaded four-column vertical press with side housings provided the most stable design. To attain maximum alignment between the extrusion ram and the powder basket, a moving platen with gibs guided by machined surfaces on the side housings was recommended.

From the numerous safety features proposed for relieving excessive pressure buildup in the basket during extrusion in case of propellant ignition, the following devices were selected as offering the best protection against major equipment damage and serious injury to operating personnel: (1) a rupture disc in the main hydraulic

cylinder, (2) a die relief platen with air sensing device to drop the die plate quickly in case of overpressure, (3) positive mechanical stops on the ram to limit downward travel, and (4) a shear ring on the die-plate holder.

Engineering drawings (Appendix A NPP Drawing No. 5627, sheets 1,2,3 and 4 and 5253) were prepared, which incorporate all press design features determined to be essential for the safe and efficient extrusion of high-energy casting powders. Only essential dimensions have been specified on these drawings, and other design features have not been rigidly delineated except where dictated by actual processing requirements. Great care was taken to minimize inclusion of proprietary design features that would unduly limit reputable press manufacturers in bidding on fabrication of this press.

Engineering specifications (Appendix B) were written for a complete 12-inch extrusion-press system including the press, hydraulic power unit, control panel, instrumentation, and electrical controls. Special materials of construction and tolerances have been specified, where necessary, to operational and safety requirements. Specification of the hydraulic power unit has been limited to the listing of operational characteristics required, i. e. a normal press cycle and special press cycle features are described. The press manufacturer working closely with the hydraulic power unit manufacturer is most qualified to determine the specific hydraulic equipment and controls required.

CONCLUSIONS

The engineering drawings and specifications developed by authority of this task assignment can form the basis for a bid package and contract award for fabrication of a modern design replacement for existing 1938 design 12-inch propellant extrusion presses.

A press built in accordance with the drawings and specifications evolved will provide an extrusion press which incorporates design features essential to the safe and efficient extrusion of high-energy casting powders.

Positive alignment (elimination of metal-to-metal contact potential) of the extrusion ram with the propellant basket under normal loading is insured by the use of the prestressed four column, side housing, and guided platen design. The existing extrusion presses at NPP have none of these design features.

Four independent acting safety devices (exclusive of those proposed in the hydraulic circuit) are incorporated into the design of the proposed extrusion press to prevent or relieve abnormal overpressures generated by a fire or explosion and minimize property damage and personnel injury. No overpressure relief devices exist on the present 12-inch extrusion presses, except in the hydraulic circuits.

RECOMMENDATION

It is recommended that authorization and funding be provided to obtain bids and award a contract for the fabrication of one extrusion press complete according to the design and specifications included in this report. Cost of the press is estimated at \$85,000 with 6 months delivery time. The new press would be used as a spare for the existing presses in the Polaris-high-impulse line and be available as a replacement in case of an incident. Spare presses of the old design are available at NPP. After consideration of the past incident record of these presses and with a new design available, it is strongly recommended that a new design press be available as a replacement.

Appendix A

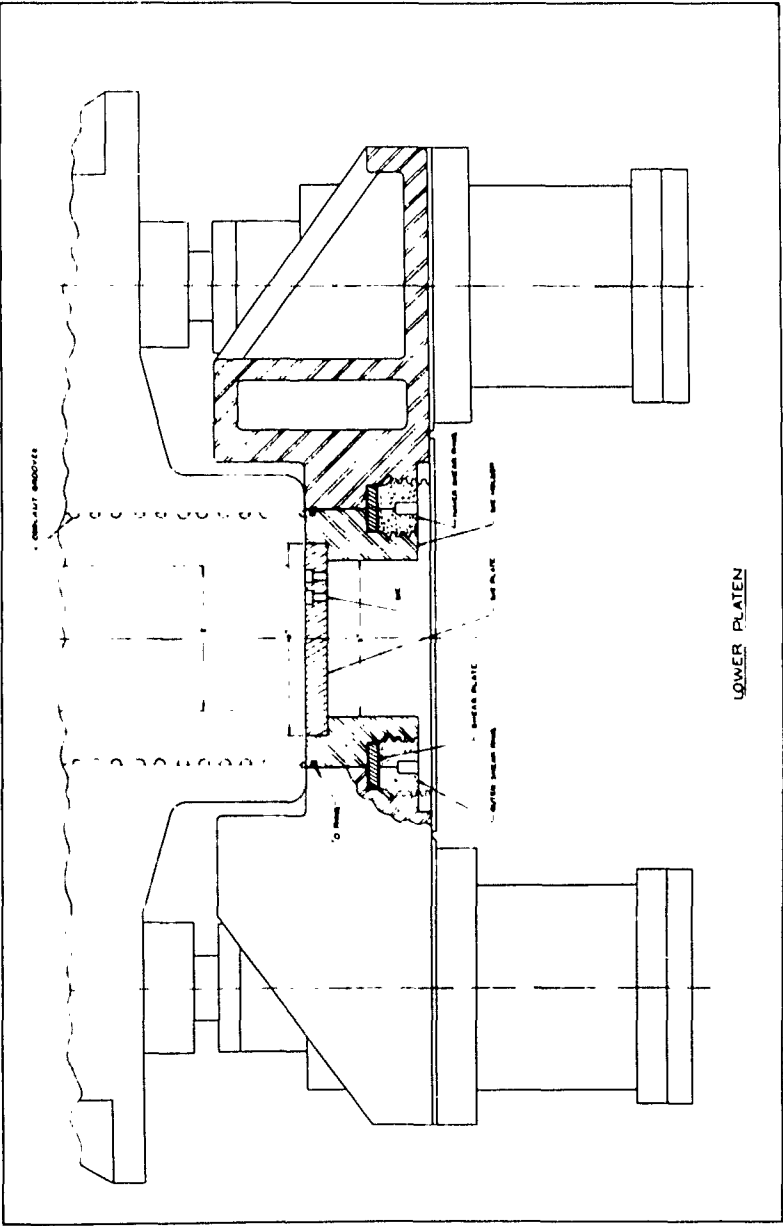
12-INCH POWDER FINISHING PRESS

NPP 5627

SHIELD, HEATING

NPP 5253

NPP 5627
Sheet 2 of 4







Appendix B

SPECIFICATIONS

Nominal 500-Ton Propellant Extrusion Press

General:

Labor and material to furnish one nominal 500-ton vertical extrusion press for processing Class A propellants with nominal 12-inch diameter press basket, complete with hydraulic power unit, control panel, instrumentation and electrical controls, die-plate stacker, and strand distributor cone.

U. S. Naval Propellant Plant drawings NPP 5627 (sheets 1, 2, 3 and 4) and NPP 5253 of Appendix A outline general features required for this extrusion press. (Note: Dimensions indicated on these drawings are obligatory; all other dimensions are at the discretion of the supplier subject to first-class propellant press design.)

1 Extrusion Press

1.1 Capacity (Nominal)

- 1.1.1 500-Ton vertical extrusion press which shall develop 3000 psi hydraulic pressure in main cylinder.
- 1.1.2 Basket shall be nominal 12-inch diameter and hold three propellant blocks 10 inches long, each block weighing approximately 55 pounds.
- 1.1.3 Production capacity shall be 3000 pounds of propellant strands per 24 hours (44 dies per die plate) using fastest composite cycle as given in Section 2.1.

1.2 Main Hydraulic Cylinder

- 1.2.1 Single-acting type cylinder integrally cast with top platen.
- 1.2.2 Cylinder and gland bores fitted with bronze bushings of ample length, equipped with outside packing compatible with petroleum-base Texaco Rando Oil A hydraulic oil or equivalent, and packing readily removable for replacement without major press dismantling. If packing is necessary in upper portion of cylinder, head of hydraulic cylinder shall be removable (flanged) and provisions made for raising ram and exposing packing for replacement.
- 1.2.3 Hydraulic oil leakage shall be prevented from contaminating propellant (Detail 2 NPP Dwg. 5627, Sheet 3 for recommended construction).
- 1.2.4 Provide sufficient vents for escape of entrapped air in main hydraulic cylinder.

- 1.2.5 Rupture disc which fails at hydraulic pressure of 4500 psi with return pipe to hydraulic power unit sump or suitable reservoir.
- 1.3 Pull-Back Cylinders
 - 1.3.1 Two hydraulic cylinders for returning press ram to "up" position.
 - 1.3.2 Maintain moving platen level accuracy on downward and return strokes within 0.001 inch throughout range of travel.
 - 1.3.3 Cylinders shall require minimum maintenance, and oil leakage shall be prevented from contaminating propellant.
- 1.4 Hydraulic Ram
 - 1.4.1 Smooth close-grained casting cored on the inside to reduce weight.
 - 1.4.2 Large wear surface with cylinder and gland bushings for long trouble-free life.
- 1.5 Moving Platen
 - 1.5.1 Guide member between the hydraulic ram and the extrusion ram which shall maintain center-line of extrusion ram coincident with center-line of the basket within ± 0.003 inch when measured at 70° F.
 - 1.5.2 Four 45° gib arrangements utilizing push-pull bolt method for alignment of press parts (front to back, left to right adjustment). Micarta Grade 273 liners with maximum bearing surface with the machined surfaces of the side housing (Detail 4, NPP Dwg. 5627, Sheet 3).
 - 1.5.3 Platen designed to take full press tonnage when down on stops.
 - 1.5.4 Positive mechanical stops for downward travel of extrusion ram and lowest projections of ram head to within 1-inch maximum of top of die plate (Detail 1, NPP Dwg. 5627, Sheet 3).
 - 1.5.5 Provide with tapered socket for centering the extrusion ram (NPP Dwg. 5627, Sheet 1 for details).
- 1.6 Extrusion Ram
 - 1.6.1 Provide with tapered end to center it in the moving platen (Detail: Press Ram, NPP Dwg. 5627, Sheet 3) and bolting flange to rigidly secure it. Bolting flange with push bolts for jacking ram out of tapered seat when required. Material - alloy forged steel.
 - 1.6.2 Ram head shall be of aluminum alloy (designation 7075 T-6) as detailed on NPP Dwg. 5627, Sheet 4. Bottom and sides of the ram head shall have a No. 64 finish.

- 1.6.3 Ram head readily replaceable (threaded into extrusion ram and suitably gasketed to eliminate cracks, crevices, and strains).
- 1.6.4 Clearance between the ram head and the powder basket shall be 0.018 inch on the diameter when measured at 70° F.
- 1.7 Side Housing
 - 1.7.1 Two upright spacing members enclosing the columns, with large contact machined surfaces with the moving platen for positive alignment between the main cylinder, extrusion ram, and basket platen.
- 1.8 Columns
 - 1.8.1 Four forged steel columns so spaced as to be equally loaded and provide for top loading of press between two columns.
 - 1.8.2 Columns shall be prestressed at a load greater than the working tonnage (500 tons) of the press.
 - 1.8.3 Prestressing shall eliminate elastic stretch of the columns during normal operation of the press and lock the main cylinder, side housings, and basket platen into one rigid structural member free from distortion in any direction.
- 1.9 Bottom Platen
 - 1.9.1 Stationary lower structural member of the press frame bored to hold the extrusion basket.
 - 1.9.2 Fitted with extended foot brackets for bolting the press to the structural supporting frame work and two positive mechanical stops for limiting downward travel of ram head.
- 1.10 Basket Liner
 - 1.10.1 Cylindrical container for holding the propellant blocks to be extruded, nominal diameter 12 inches. Clearance between ram head and basket liner shall be 0.018 inch on diameter when measured at 70° F.
 - 1.10.2 Basket liner to be replaceable (removable) and made of alloy forged steel. (See Detail on NPP Dwg. 5627, Sheet 2).
 - 1.10.3 Heating-cooling grooves for circulation of water, suitably gasketed to eliminate water leakage (maximum pressure, 125 psi; maximum temperature, 120° F).
 - 1.10.4 Inner bore shall have a No. 16 finish.
- 1.11 Die Relief Platen

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- 1. 11. 1 Movable platen for supporting die plate against basket in bottom platen and also powder strand cone distributor (NPP Dwg. 5627, Sheet 2 for details).
- 1. 11. 2 Platen provided with four movable hydraulic cylinders against stationary pistons attached to each of the column extensions and provided with accumulator or other suitable device to make up leakage.
- 1. 11. 3 Four cylinders shall provide pressure overload protection which drop the die-relief platen 1/4 inch within a 6-millisecond time period when an overload of 100 tons in excess of the holdup force is exerted. Maximum tonnage at which the die-relief platen will relieve shall be presettable, and adjustable in the range 500-750 tons.
- 1. 11. 4 Maximum travel downward of the die-relief platen shall be sufficient to permit ready removal of the die plate for cleaning and replacement.
- 1. 11. 5 Inner and outer shear rings with shear plate which will fail at 750 tons pressure and permit rapid ejection of the die plate and holder (Details NPP Dwg. 5627, Sheet 2). Two spare shear ring plates shall be provided with each press.
- 1. 11. 6 Air detection device (Moore Product Co., Philadelphia, Pa., suggested supplier) which will indicate contact between the die plate and the bottom surface of the basket and bottom platen. Device shall detect movement of 0.002-inch opening in 7 milliseconds or less and produce signal which will put the main and die plate holdup hydraulic cylinders on exhaust, secure hydraulic press systems, and operate indicating light at the control station.
- 1. 12 Die Plate and Holder
 - 1. 12. 1 Die plate held in close fitting ring centered in bore in the die relief platen (NPP Dwg. 5627, Sheet 2 for details).
 - 1. 12. 2 Die plate, to be furnished by vendor, shall be a solid plate (no holes for die insertion) and fabricated from type 4340 aircraft quality steel.
- 1. 13 Die Plate Removal Device
 - 1. 13. 1 One manually operated portable stacker with 1000-pound maximum load capacity.
 - 1. 13. 2 Die plate shall be supported on pedestal (by others) as die-relief platen is lowered.
 - 1. 13. 3 Stacker shall be pushed into position, forks of stacker centered under die plate, cranked up until forks contact and support the die plate, and roll the stacker away from the press.
 - 1. 13. 4 Stacker shall have maximum stability, conductive-rubber tired wheels, good maneuverability, and positive position lock.

1.14 Strand Distributor Cone

- 1.14.1 Device containing 44 Teflon tubes, OD of 29/32 inch, (by others) which connect to the dies (by others) in the die plate and guide the propellant strands into powder buckets (by others).
- 1.14.2 Aluminum-plexiglass enclosure to permit hot-air heating of tubes.
- 1.14.3 Device shall be similar to that shown on NPP Dwg. 5253.
- 1.14.4 Cone device to be affixed to die-relief platen and move up and down with this platen. Device to be readily removable for replacement of Teflon tubes.

2 Hydraulic Power Unit and Controls

The power unit shall consist of two or more radial piston variable-delivery type pumps, the main pump and the die holder pump will be complete with suitable valving, controls, operating panel, and electrical starters. Hydraulic power units shall be manufactured by the OILGEAR Company, Milwaukee, Wisconsin. The pumps will be located 100 to 150 feet away from the press. Any electrical equipment which must be placed within 50 feet of the press shall meet National Electrical Code Division 1, Class I, Group C and D, Class II, Group E, F and G. Smoothness of press operation is essential during all phases of the extrusion cycle, i.e., acceleration and deceleration rate shall be minimum.

With each bid shall be submitted a press cycle chart and electrical and hydraulic circuit diagram(s) for review and approval prior to awarding of a contract.

2.1 Normal Press Cycle

- 2.1.1 Depress ON button - both pumps activated.
- 2.1.2 Depress UP button - open press, retract ram by pumping oil to pull back cylinders and moving platen to uppermost position.
- 2.1.3 Depress DIE CLOSE button - close die plate, oil pumped to four die plate holding hydraulic cylinders, accumulator pumped up, air detection device activated.
- 2.1.4 Depress CYCLE button - start press cycle, ram descends at 4 in/min rate until limit switch contacted (adjustable, 1-3 inches above powder height), when ram slows down to compacting speed of 0.4 in/min (adjustable rate, 0.1-0.7 in/min); as compacting occurs, pressure switch (adjustable, 600-1500 psi) activated at preset pressure and ram speed changes to 1.0 in/min (adjustable rate, 0.5-2.5 in/min); after approximately one-third of charge is extruded, motion of press ram stopped by pressing HOLD button and main ram decompressed.

- 2.1.5 Depress CYCLE CONTINUE button - restarts press cycle, ram continues down motion at 0.4 in/min (adjustable), as compacting occurs, pressure switch (adjustable) activated at preset pressure and ram speed changes to 1.0 in/min (adjustable); extrusion continued until limit switch is contacted and/or moving platen contacts positive mechanical stops, press ram stopped and main ram decompressed.
- 2.1.6 Depress UP button - extrusion ram retracted by directing pump volume to pullback cylinders, ram return speed 25 in/min (adjustable rate, 20-30 in/min); ram retracts until at top of stroke limit switch is contacted, ram stops, main pump on bypass.
- 2.1.7 Depress DIE OPEN button - die-relief platen lowered by deactivating air detection device and releasing hydraulic pressure on four die plate holding cylinders and exhausting accumulator.
- 2.1.8 Depress STOP button - all hydraulic pumps off.
- 2.2 Special Press Cycle Features
 - 2.2.1 EMERGENCY STOP button - kills all control circuit 110-v power except that to pump drive motor starters, alarm circuitry; automatic decompression initiated.
 - 2.2.2 RESET button - inside relay panel and permits clearing an emergency stop condition. Assuming emergency is cleared, depress START button to initiate ram motion.
 - 2.2.3 HOLD button - stops further motion of ram and holds last position, automatic decompression initiated; hold position can be obtained by depressing HOLD button, or automatically if alarm condition occurs, or UP button depressed during downward stroke; on downward stroke motion reactivated only by depressing START button; on upward stroke motion reactivated only by depressing UP button.
 - 2.2.4 Die-relief platen pump shall be interlocked such that cycle START button cannot be actuated unless die-relief platen pump is in operation and has developed full operating pressure. Other suitable interlocks shall be provided including interlocks for press bay doors which prevent operation of press unless doors are properly closed.
- 2.3 Control Panel
 - 2.3.1 Warning and operating lights - red light indicates an emergency condition, green light indicates normal operating condition, white light indicates both pump drive motor starters activated.

- 2.3.2 Remote ram position indicator shall operate position control limit switches and position scale is to be hydraulic either by slave cylinder or by rotary hydraulic motor driving along screw. Indicator must indicate ram position at all times within $\pm 1/16$ inch of the actual position with reproducibility of $\pm 1/64$ inch.
- 2.3.3 All operating controls, warning lights, position indicator shall be supplied by the vendor mounted on a suitable panel or in a cabinet, components pre-wired within the control panel, and their function indicated by suitably engraved nameplates.
- 3 Services to be Furnished
 - 3.1 With each bid shall be submitted a word description of press operation, a press cycle chart, and bill of materials for review prior to awarding of a contract.
 - 3.2 The successful bidder shall submit for review and approval prior to start of actual fabrication of component procurement detailed drawings and/or commercial brochures describing all components to be supplied under this contract.
 - 3.3 The press with controls and hydraulic systems complete shall be set up in the vendor's plant and test run in the presence of NPP representatives to insure that the specifications are met prior to shipment to NPP.
 - 3.4 Final acceptance of the press shall be made at NPP, Indian Head, Maryland, after installation and checkout of all components supplied under this contract.
 - 3.5 Technical supervision shall be supplied by the vendor or his designated representative during installation of the press and components at the Naval Propellant Plant.
 - 3.6 Within 90 days after date of contract, five copies of certified foundation drawings shall be furnished to permit installation design by NPP.
 - 3.7 One set of reproducible final drawings and/or commercial brochures describing all components to be supplied under this contract, maintenance manuals and recommended operating procedures shall be furnished by the vendor upon delivery of the press to NPP.

This report is distributed to the
Chemical Propulsion Mailing List
of June 1963.

<p>Naval Propellant Plant, Indian Head, Maryland (NavWeps Report 8451) DESIGN OF 12-INCH EXTRUSION PRESS(U). (TR 133) 27 June 1963. 21 pp.</p> <p>Based on design studies for a high-energy propellant extrusion press completed during fiscal year 1962 by the Farrel-Birmingham Company, Inc. and the Ferracuta Machine Company, engineering drawings and specifications are presented which represent a composite of the best features submitted by the two press manufacturers. This design</p>	<ol style="list-style-type: none"> 1. Extrusion Presses-12-Inch Design 2. Extrusion Presses-Design 3. Farrel-Birmingham Co. 4. Ferracuta Machine Co. <p>I. Foust, H. C.</p>	<p>Naval Propellant Plant, Indian Head, Maryland (NavWeps Report 8451) DESIGN OF 12-INCH EXTRUSION PRESS(U). (TR 133) 27 June 1963. 21 pp.</p> <p>Based on design studies for a high-energy propellant extrusion press completed during fiscal year 1962 by the Farrel-Birmingham Company, Inc. and the Ferracuta Machine Company, engineering drawings and specifications are presented which represent a composite of the best features submitted by the two press manufacturers. This design</p>	<ol style="list-style-type: none"> 1. Extrusion Presses-12-Inch Design 2. Extrusion Presses-Design 3. Farrel-Birmingham Co. 4. Ferracuta Machine Co. <p>I. Foust, H. C.</p>
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